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“Knowledge is such a treasure which cannot be stolen”

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Indian Standard

SPECIFICATION FOR
ELECTROPLATED COATINGS OF GOLD
FOR DECORATIVE PURPOSES

(*First Revision*)

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INDIAN STANDARDS INSTITUTION
MANAK BHAVAN, 9 BAHADUR SHAH ZAFAR MARG
NEW DELHI 110002

Indian Standard

SPECIFICATION FOR ELECTROPLATED COATINGS OF GOLD FOR DECORATIVE PURPOSES

(*First Revision*)

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Indian Standard

SPECIFICATION FOR
ELECTROPLATED COATINGS OF GOLD
FOR DECORATIVE PURPOSES
(First Revision)

0. FOREWORD

0.1 This Indian Standard (First Revision) was adopted by the Indian Standards Institution on 17 May 1982, after the draft finalized by the Metallic Finishes Sectional Committee had been approved by the Structural and Metals Division Council.

0.2 This standard specifies requirements for electroplated coatings of gold, including gold alloy, for use for general decorative and jewellery applications and for specialized applications in the jewellery trade where relatively thick coatings to withstand continuous wear over considerable periods are required. Decorative purposes are those for which the appearance of the finished article is of prime importance; although protection against corrosion may also be a requirement.

0.3 This standard was earlier published in 1967. In this revision a table on requirements for undercoats has been included, and the coating thickness and gold content limits have been revised. Methods for determination of coating thickness, including those based on atomic absorption and spectrophotometric have also been included.

0.3.1 During preparation of this standard necessary assistance has been derived from second draft proposal ISO/DP 4524 Electrodeposited coatings of gold (and gold alloy) for decorative purposes.

0.4 For the purpose of deciding whether a particular requirement of this standard is complied with, the final value, observed or calculated, expressing the result of a test or analysis, shall be rounded off in accordance with IS : 2-1960*. The number of significant places retained in the rounded off value should be the same as that of the specified value in this standard.

*Rules for rounding off numerical values (revised).

1. SCOPE

1.1 This standard specifies requirements for electroplated coatings of gold and its alloys for decorative applications on metallic and non-metallic materials.

1.2 It does not apply to coatings on machine screw threads (with tolerance) or to coatings applied on sheet, strip and wire in the unfabricated form, or to those items, such as watch cases.

2. TERMINOLOGY

2.0 For the purpose of this standard, the following definitions shall apply.

2.1 Significant Surface — That area of the article covered, or to be covered by the coating and for which the coating is essential for serviceability and/or appearance.

2.2 Gold Coating — An electroplated coating of gold or gold alloy having a minimum thickness of not less than $0.5\text{ }\mu\text{m}$ and a gold content of not lower than 58.5 percent (m/m).

2.3 Finished State — The condition after all finishing operations, excluding any lacquering.

3. BASIS MATERIAL

3.1 This standard specifies no requirements for the condition, finish or surface roughness of the basis material prior to electroplating. However, it should be recognized that the surface roughness of the coating will be dependent on the initial surface roughness of the basis material and this shall not, therefore, be the cause for rejection of the gold coating.

4. CLASSIFICATION NUMBER

4.1 The classification number comprises:

- a) The chemical symbol for the basis metal or the principal metal if an alloy, or, in the case of non-metallic materials, the letters NM, followed by an oblique stroke;
- b) where appropriate, the chemical symbol(s) for the undercoat metal(s) as follows:
Ni for nickel,
Cu for copper,
Cu/Ni for nickel on copper,
Sn-Ni for tin nickel alloy
followed by an oblique stroke;

- c) A figure in parenthesis given after the symbol Au representing the percentage gold content of the gold; and
- d) A number indicating the minimum thickness (in micrometres) of the gold coating on the significant surface.

Examples of complete classification numbers are as follows:

Example 1 — A coating having a gold content of at least 90 percent and thickness of $5\text{ }\mu\text{m}$ minimum on steel, using a nickel undercoat, has the classification number: Fe/Ni/Au(90)5.

Example 2 — A coating having a gold content of at least 60 percent and a thickness of $2\text{ }\mu\text{m}$ minimum on die-cast zinc alloy using undercoats of copper and nickel, has the classification number: Zn/Cu/Ni/Au(60)2.

Example 3 — A coating having a gold content of at least 75 percent and a thickness of $0.5\text{ }\mu\text{m}$ minimum on copper alloy has the classification number: Cu/Au(75)0.5.

5. REQUIREMENTS FOR UNDERCOATS

5.1 Requirements for undercoats are given in Table 1. For arduous conditions of service, greater thicknesses may be required and shall be specified by the purchaser.

NOTE — To promote good adhesion, it may be necessary to deposit a gold strike coating immediately prior to the main gold deposition.

6. REQUIREMENTS FOR GOLD COATINGS

6.1 Appearance — A preliminary sample having the required colour and finish shall be supplied or approved by the purchaser.

6.2 The electroplated article shall be clean and free from damage.

6.3 Over the significant surface, the electroplated article shall be free from clearly visible electroplating defects, such as, pits, roughness, cracks, or uncoated areas, and shall not be stained or discoloured. In addition, blistering or other signs of poor adhesion shall not be tolerated on any surface of the article. On articles where a contact mark on the significant surface is unavoidable, its position shall be agreed between the parties.

6.4 Thickness — Gold coatings are classified by thickness (*see* Note), and the preferred range is given in Table 2. Any other coating thickness above the minimum of $0.5\text{ }\mu\text{m}$ and expressed in whole numbers of micrometres, may be called up by specifying the required minimum local thickness, at the appropriate place in the classification number.

NOTE — As the density of electrodeposited gold coatings may vary, the purchaser may find it desirable to specify a minimum mass per unit area requirement in addition to the minimum thickness.

Thickness of the coatings shall be measured over a reference area by the appropriate method given in Appendix A on any part of the significant surface.

For control purposes, a number of satisfactory methods are available and are given in Appendix A. The referee method shall be the microscopic method specified in IS : 3203-1982* operating at 1 000X magnification.

TABLE 1 REQUIREMENTS FOR UNDERCOATS

(Clause 5.1)

BASIS MATERIAL	UNDERCOAT(S) REQUIRED	MINIMUM THICKNESS OF UNDERCOAT(S) μm
Copper	*None	—
Copper alloys, notably free-cutting brass containing lead	Copper, nickel or tin-nickel and silver alloy may be required	1.25
Ferrous materials (other than austenitic stainless steel)	Nickel or copper + nickel	10 10 (copper) + 5 (nickel)
Austenitic stainless steel	An acid nickel strike (Woods bath) will normally be required	Thin coating to promote adhesion of the gold coating
Zinc and zinc alloys	Copper + nickel	8 (copper) + 10 (nickel)
Aluminium and aluminium alloys	Nickel†	20
Lead and lead alloys	Copper + nickel	To be agreed
Other basis materials and basis metals with soldered joints	Nickel or copper may be required to meet functional or other requirements of this standard	To be agreed

*For flash or thin gold plating, an undercoat of nickel or silver is recommended.

†An initial copper coating may be employed under the nickel coating but the thickness of the nickel coating shall not be reduced.

TABLE 2 TYPICAL THICKNESSES OF GOLD COATINGS FOR GENERAL DECORATIVE AND JEWELLERY APPLICATIONS

(Clause 6.4)

Minimum local coating thickness

μm

0.5 — 1 — 2 — 5 — 10 — 20 — 40

*Methods of testing local thickness of electroplated coatings (first revision).

6.5 Porosity and Corrosion Resistance

6.5.1 Where corrosion resistance and/or porosity are important and if specified by the purchaser, parts having gold coatings of thickness 5 μm and over, shall be subjected to the test given in Appendix B.

6.5.2 There shall be no signs of attack on the gold plating or underlying metal on the significant surface. Any discoloration or pitting shall be considered as signs of an attack.

6.5.3 If coatings less than 5 μm in thickness are required for service in corrosive conditions and if required by the purchaser, a suitable test for corrosion resistance of the composite coating (gold coating or any undercoats) shall be specified.

6.6 Gold Content — The gold content of the coating shall be determined by the appropriate method given in Appendix C.

6.7 Adhesion — Coatings shall be capable of passing one or more of the adhesion tests given in 6.7.1 to 6.7.4 as specified by the purchaser.

NOTE — The preparation of cross-sections for metallographic thickness measurement often provides an indication of poor adhesion. The action of grinding and polishing creates a shear force which may often cause the separation of the coating from the substrate, and this separation may be observed in the measuring microscope. If such a thickness test has already been carried out and this shows poor adhesion of the coating, it is unnecessary to perform further tests for this property.

6.7.1 Burnishing Test — When the specimen is tested by the method specified in D-1, there shall be no sign of blistering or detachment of the coating.

6.7.2 Adhesive Tape Test — When the specimen is tested by the method specified in D-2, no part of the coating shall be removed by the adhesive tape.

6.7.3 Thermal Shock — When the specimen is tested by the method specified in D-3, there shall be no sign of blistering or detachment of the coating.

6.7.4 Bend Test — When the specimen is tested by the method specified in D-4, it shall withstand three bends without detachment of the coating.

NOTE — Failure of the substrate due to micro- or macro-cracking shall not be the cause for rejection provided that the coating does not exfoliate.

6.8 Hardness — If a value for hardness is specified, the hardness of the coating shall be determined as micro-hardness. Knoop hardness methods are specified in IS : 9530-1980*.

*Method of testing micro hardness of electroplated coatings.

7. MARKING

7.1 Gold plated articles shall be marked with the grading, and name or trade-mark of the manufacturer. In case it is impracticable to mark the coated article, a label marked with the grading, purity of coating and name or trade-mark of the manufacturer shall be securely attached to the article.

7.1.1 Gold plated articles may also be marked with the ISI Certification Mark.

NOTE — The use of the ISI Certification Mark is governed by the provisions of the Indian Standards Institution (Certification Marks) Act and the rules and regulations made thereunder. The ISI Mark on products covered by an Indian Standard conveys the assurance that they have been produced to comply with the requirements of that standard under a well-defined system of inspection, testing and quality control which is devised and supervised by ISI and operated by the producer. ISI marked products are also continuously checked by ISI for conformity to that standard as a further safeguard. Details of conditions under which a licence for the use of the ISI Certification Mark may be granted to manufacturers or processors, may be obtained from the Indian Standards Institution.

8. SAMPLING AND INSPECTION

8.1 Sampling for Acceptance of a Lot — For the purpose of acceptance, a lot shall be divided into sub-lots consisting of 100 articles or part thereof of such articles as are electroplated at one time in the same batch. Two samples shall be selected from each sub-lot and subjected to the appropriate tests.

8.2 Visual Inspection — From each lot 20 articles shall be selected at random and be examined for appearance and other usual characteristics (*see* **6.1** and **6.2**). The lot shall be accepted under this clause, only if all the sample items satisfy the requirements.

8.3 Thickness and Other Requirements — Two items shall be selected from each lot to be tested for thickness and other requirements (**6.4** to **6.8**). If one or both the samples fail, two further samples shall be tested for each failure. If these samples pass the tests, the lot shall be accepted. If any of the sample fails, the lot shall be rejected.

NOTE — The above sampling inspection plan is recommended as a general guidance. Any modification shall be subject to agreement between the supplier and the purchaser.

APPENDIX A

(Clause 6.4)

DETERMINATION OF COATING THICKNESS

A-1. INTRODUCTORY NOTES

A-1.1 The methods given in this Appendix are those which are considered to have an adequate accuracy when properly used with test specimens suitable for the particular method. If a referee method is required, it shall be selected from the test methods given in A-2 to A-4. The method chosen shall be one which is expected to yield the most reliable results considering such factors as coating thickness, shape and size of component, coating material, basis material, etc. Other test methods may be used, if it may be demonstrated that they have an accuracy of ± 10 percent or better, or that they are as good as or better than the methods given in this Appendix for the particular application.

A-2. MICROSCOPICAL METHOD

A-2.1 The method given in IS : 3203-1982* is considered to have an accuracy of ± 10 percent or $\pm 0.8 \mu\text{m}$, whichever is the greater value.

A-3. GRAVIMETRIC METHOD

A-3.1 Principle — Chemical or electrochemical dissolution of the substrate without attack of the gold coating. Calculation of the average thickness of the coating over a small area from the area, mass and density of the coating.

A-3.2 Test Specimen — Carefully punch or cut the test specimen from the article. The shape and size of the specimen shall be such that the area of gold may be measured with an accuracy of 2 percent or better, and the mass of gold may be subsequently determined with an accuracy of 2 percent or better. It may be necessary to square off and sand the edges to remove gold smeared over the edge by the cutting operation.

A-3.3 Procedure

A-3.3.1 Measure the area of coating with an accuracy of 2 percent or better.

A-3.3.2 Remove as much as possible of the basis material by mechanical means before stripping in order to minimize potential attack on the gold coating.

*Methods of testing local thickness of electroplated coatings (*first revision*).

A-3.3.3 Dissolve the substrate material without attacking the coating. For many substrates, nitric acid ($rd = 1.42$) diluted with three volumes of water may be used at approximately 25°C but this acid may dissolve some of the alloying elements in the case of some alloy coatings.

A-3.3.4 Remove the gold, dry at 110°C for approximately 30 minutes, and weigh to an accuracy of 2 percent or better. If the gold breaks up into small pieces, it may be necessary to filter and weigh the residue by normal analytical technique.

A-3.4 Calculation

The average coating thickness in micrometres, is given by the formula:

$$\frac{10 m}{A \times rd}$$

where

m = is the mass of the coating, in milligrams;

A = is the area of the gold-plated surface of the specimen, in cm^2 ; and

rd = is the density of the coating in g/cm^3 .

NOTE — The density of pure gold is 19.3 g/cm^3 . Electroplated gold often has a lower density because of included organic material or co-deposited alloying metals. If the true density of the coating is not known, use the value 19.3 g/cm^3 but the calculated thickness may then be considerably less than the true thickness.

A-4. CHEMICAL, SPECTROPHOTOMETRIC AND AAS METHODS

A-4.1 Principle — Removal of the basis material from a small known area (the test specimen) of the article, taken from a desired point. Dissolution of the gold in aqua regia. Spectrophotometric or atomic absorption spectrometric determination of the mass of gold in the test solution and hence on the test specimen. Calculation of the average thickness of the gold coating on the test specimen from its area and mass and from the density of the gold coating.

A-4.2 Reagents — Use only reagents of recognized analytical grade and only distilled water or water otherwise obtained of equivalent purity.

A-4.3 Apparatus — Thoroughly clean all glassware, including the spectrophotometer cells, with the aqua regia (**A-4.5.1.2**) and rinse with water before use. It is preferable to reserve glassware solely for use with these analyses.

A-4.4 Test Specimen — Carefully punch or cut a test specimen from the article so that its area may be measured with an accuracy of 2 percent or

better and so that the mass of gold can be determined subsequently with an accuracy of 2 percent or better. It may be necessary to square off and sand the edges to remove any gold smeared over the edge by the punching or cutting operation.

A-4.4.1 The accuracy of the thickness measurements depends largely on the accuracy with which the area of the test specimen is measured. For articles made from sheet materials, accurately sized test specimens may be taken conveniently by using a punch and die to give discs of known diameter. For gold electroplated pads or printed wiring boards, the copper foil may usually be detached mechanically. If necessary, the pads may be detached from the laminate by boiling in 200 g/l sodium hydroxide solution.

A-4.4.2 The quantities of reagents and the dilutions specified in the following procedures are related to an area of 0.1 cm², which is the smallest test specimen that should be taken. If larger areas are taken, adjust the dilutions and the volumes of the aliquot portions of the test solution accordingly.

A-4.5 Preparation of Test and Standard Solution

A-4.5.1 Reagents

A-4.5.1.1 Nitric acid — *rd* approximately 1.2, about 40 percent (*V/v*) solution.

A-4.5.1.2 Aqua regia — Add 25 ml of concentrated nitric acid (*rd* approximately 1.42) to 75 ml of concentrated hydrochloric acid solution (*rd* approximately 1.18). Prepare just before use.

A-4.5.2 Test Solution — Remove as much as possible of the basis material from the test specimen (**A-4.4**) by mechanical means before stripping in order to minimize potential attack on the gold coating. Separate the coating from the remaining basis material by dissolving the latter in the nitric acid solution (**A-4.5.1.1**). Wash and dry the stripped coating and dissolve it in 3 ml of the hot aqua regia (**A-4.5.1.2**) in a 50-ml beaker.

A-4.5.3 Standard Solution

A-4.5.3.1 Reagent — Dissolve 0.050 g of 'proof' gold, purity 99.99 percent (*m/m*) in 20 ml of the aqua regia (**A-4.5.1.2**) and dilute with water to the mark in a 1 000-ml one-mark volumetric flask.

A-4.5.3.2 Preparation of standard solutions — Into a series of six of the 50-ml beakers (**A-4.6.3.2**), place the volumes of the standard gold solution (**A-4.5.3.1**) shown in Table 3.

NOTE — For lower ranges of thickness, dilute the standard gold solution five fold.

TABLE 3 STANDARD SOLUTION

(Clause A-4.5.3.2)

VOLUME OF STANDARD GOLD SOLUTION (A-4.5.3.1)	CORRESPONDING MASS OF GOLD	CONCENTRATION OF GOLD IN FINAL SOLUTION
ml	mg	mg/ml
0*	*	0*
1.0	0.05	0.005
2.0	0.10	0.010
4.0	0.20	0.020
6.0	0.30	0.030
8.0	0.40	0.040

*Compensation solution.

A-4.6 Spectrophotometric Method

A-4.6.1 Principle — Addition of potassium chloride to the test solution to give stable gold potassium chloride. Evaporation to dryness and spectrophotometric determination of the gold content.

Basis metals that have soluble colourless chlorides and copper, nickel, cobalt and iron, that have coloured chlorides, do not interfere. The method is, therefore, suitable for gold coatings containing such metals. In the case of gold coatings containing alloying metals, such as, silver, that have insoluble chlorides, it may be necessary to filter the solution before measuring the absorbance.

A-4.6.2 Reagents

A-4.6.2.1 Potassium chloride — 10 g/l solution.

A-4.6.2.2 Hydrochloric acid — 20 percent (V/V) solution. Dilute 200 ml of concentrated hydrochloric acid solution (rd approximately 1.18) to 1 000 ml.

A-4.6.3 Apparatus — Ordinary laboratory apparatus.

A-4.6.3.1 Spectrophotometer — fitted with 10 mm and 40 mm silica cells.

A-4.6.3.2 Beakers — 50 ml capacity, squat form. At least six are required.

A-4.6.3.3 Micro-filter funnel — fitted with a sintered glass filter plate or a suitable filter stick.

A-4.6.3.4 Electric oven — capable of being maintained at $110 \pm 2^\circ\text{C}$.

A-4.6.4 Preparation of Calibration Graph

A-4.6.4.1 Preparation of standard colorimetric solutions — Treat the contents of each beaker of standard solution (**A-4.5.3.2**) as follows:

Add 1 ml of the potassium chloride solution (**A 4.6.2.1**), evaporate carefully to incipient dryness on a hot-plate or water bath, dry in the oven (**A-4.6.3.4**), maintained at $110 \pm 2^\circ\text{C}$, and allow to cool. Redissolve the residue in 10 ml of the dilute hydrochloric acid solution (**A-4.6.2.2**).

A-4.6.4.2 Spectrophotometric measurements — Carry out the spectrophotometric measurements of the standard colorimetric solutions (**A-4.6.4.1**) in the spectrophotometer (**A-4.6.3.1**) at a wavelength of 312 nm and using 10 mm cells, after having adjusted the instrument to zero absorbance against water.

A-4.6.4.3 Plotting the calibration graph — Deduct the absorbance of the compensation solution from those of the standard colorimetric solutions. Plot a graph of the concentrations, in milligrams of gold per millilitre, as abscissas against the corresponding net values of absorbance as ordinates. A straight line should be obtained.

A-4.6.5 Determination — Carry out the determination in duplicate, starting from two different test specimens (**A-4.4**). Add 1 ml of the potassium chloride solution (**A-4.6.2.1**) to the test solution (**A-4.5.2**) and evaporate carefully to incipient dryness on hot-plate or water bath. Dry in the electric oven (**A-4.6.3.4**), maintained at $110 \pm 2^\circ\text{C}$ and allow to cool. Redissolved the residue in the hydrochloric acid solution (**A-4.6.2.2**) in a one-mark volumetric flask of capacity indicated in Table 4, and dilute to the mark with same acid.

TABLE 4 VOLUMES OF DILUTION AND CELL SIZES FOR VARIOUS THICKNESSES OF COATING

APPROXIMATE COATING THICKNESS	CAPACITY OF ONE-MARK VOLUMETRIC FLASK	CELL SIZE
micrometres	mm	mm
5.0 to 10.0	20	10
1.25 „ 5.0	10	10
0.1 „ 1.25	10	40

Measure the absorbance of the solution in the spectrophotometer (**A-4.6.3.1**) at a wavelength of 312 nm and using the appropriate cell indicated in Table 4, after having adjusted the instrument to zero absorbance against the blank test solution (**A-4.6.6**).

A-4.6.6 Blank Test — Carry out a blank test at the same time as the determination, following the same procedure and using the same quantities of all the reagents, but omitting the test specimen.

A-4.7 Atomic Absorption Spectrometric (AAS) Method

A-4.7.1 Principle — Addition of lanthanum chloride to the test solution to suppress interferences and measurement of the atomic absorption.

A-4.7.2 Lanthanum Chloride — approximately 100 g/l solution.

Dissolve approximately 58.6 g of lanthanum oxide in 250 ml of concentrated hydrochloric acid (rd approximately 1.18) and dilute to 500 ml with water.

A-4.7.3 Apparatus — Ordinary laboratory apparatus.

A-4.7.3.1 Atomic absorption spectrometer

A-4.7.4 Preparation of Calibration Graph

A-4.7.4.1 Preparation of standard matching solutions — Treat the contents of each beaker of standard solution (A-4.5.3.2) as follows:

Transfer to a series of six 100-ml one-mark volumetric flasks, add 4 ml of the lanthanum chloride solution (A-4.7.2) and dilute to the mark with water.

A-4.7.4.2 Spectrometric measurements — Aspirate the standard matching solutions (A-4.7.4.1) directly into the flame of the atomic absorption spectrometer (A-4.7.3.1), using the conditions for gold determination specified by the instrument manufacturer, and record the absorbance readings.

A-4.7.4.3 Plotting the calibration graph — Deduct the absorbance of the compensation solution from those of the standard matching solutions. Plot a graph of the concentrations, in milligrams of gold per millilitre, as abscissae against the corresponding net values of absorbance as ordinates.

A-4.7.5 Determination — Transfer the test solution (A-4.5.2) to a one-mark volumetric flask of capacity indicated in Table 5, add the indicated volume of the lanthanum chloride solution (A-4.7.2.1) and dilute to the mark.

TABLE 5 VOLUMES OF DILUTION AND OF LANTHANUM CHLORIDE SOLUTION FOR VARIOUS MASSES OF GOLD

MASS OF GOLD IN TEST SPECIMEN	CAPACITY OF ONE- MARK VOLUMETRIC FLASK	VOLUME OF LANTHANUM CHLO- RIDE SOLUTION (A-4.7.2)
mg	ml	ml
Up to 0.2	10	0.4
0.2 to 2	100	4
2 to 20	1 000	40

Measure the absorbance of the resultant solution as described in A-4.7.4.2.

A-4.8 Calculation — The average coating thickness, in micrometres, is given in the expression:

$$\frac{m_1 \times 10}{A \times rd} \times \frac{100}{P}$$

where

- m_1 = mass, in milligrams, of gold in the test solution, calculated from the calibration graph (A-4.6.4 or A-4.7.4) and the total volume of the final test solution (see Tables 4 and 5);
- A = area, in square centimetres, of the test specimen (A-4.4);
- rd = density, in grams per cubic centimetre, of the coating; and
- P = gold content, as a percentage by mass, of the coating (see Appendix C).

APPENDIX B

(Clause 6.5.1)

CORROSION TEST

B-1. SULPHUR DIOXIDE EXPOSURE TEST*

B-1.1 This test is suitable for application with all undercoats and substrates. The generation of sulphur dioxide from known reagents inside the test vessel permits an easy control of the atmosphere composition. A suitable test vessel is a container made of glass or acrylic resin of about 10 litres capacity, capable of being closed by a gas-tight cover or door. A conventional 10 litres desiccator vessel is recommended. Provision shall be made for the support of test specimens within the vessel so that they are about 100 mm above its base. The specimens may be suspended from rods by means of suitable material, for example, nylon thread or glass hooks. All materials used for chamber construction or specimen support shall be non-metallic and inert to the action of sulphur dioxide; glass and resin are suitable materials.

B-1.2 The test temperature shall be maintained within a temperature range agreed as being suitable for the materials under test and for a selected duration of test.

*Attention is drawn to the toxic hazards of sulphur dioxide; the test vessels, at least during filling and opening, should be placed under a suitable extraction hood.

B-1.3 During the test, the test vessels shall be kept screened from draughts or from any source of local radiant heat so that sudden temperature fluctuations and local heating of the test chamber are avoided.

B-1.4 Introduce 200 ml of a 200 g/l sodium thiosulphate solution into the test chamber and add to it 50 ml of 50 percent (v/v) sulphuric acid ($rd = 1.84$). Place the test specimens immediately in the vessel so that they are not less than 75 mm above the surface of the liquid and not less than 25 mm from the walls. Close the vessels immediately and move it gently to ensure complete mixing of the two solutions.

B-1.5 After the end of the test period, open the test chamber, remove and inspect the test specimens. Two recommended test periods are 24 hours at $25 \pm 5^{\circ}\text{C}$ and 2 hours at $60 \pm 3^{\circ}\text{C}$.

APPENDIX C

(Clause 6.6)

DETERMINATION OF GOLD CONTENT

C-1. INTRODUCTORY NOTES

C-1.1 The gold coating is first removed from the basis material and undercoats (if any) as described in **C-2**. The gold content is then determined by one of the methods described in **C-3** or **C-4**.

C-1.2 With certain gold alloy coatings having a gold content of less than about 90 percent, there is a possibility that some of the alloying element may be dissolved in the nitric acid solution during removal of the coating from the basis metal. If this should occur, erroneously high results may be obtained. In such cases, samples of gold coatings which may be mechanically stripped shall be supplied.

C-1.3 A high degree of precision in weighing is essential to attain sufficient accuracy of results, and relatively large samples may be required. If necessary, special thickly plated samples may be prepared for the purpose. However, test samples need not be limited to selected areas of articles and they may consist of one or more entire small articles from a plated batch, or samples may be taken from the more heavily plated areas (including outer and edge areas) of large articles.

C-1.4 The methods given in **C-3** and **C-4** are recommended for determining the gold content of gold coatings containing less than 99 percent gold but other methods, for example, the electron microprobe method, may be used.

C-2. REMOVAL OF GOLD COATING FROM BASIS METAL AND UNDERCOATS (IF ANY)

C-2.1 Cut or otherwise remove a suitable piece or pieces from the sample or, if necessary, take an entire article or articles and cut into suitably sized pieces. Remove as much as possible of the basis material by mechanical means prior to stripping in order to minimize potential attack on the gold coating. Place in a small beaker and add a quantity of dilute nitric acid (1 volume of concentrated acid *rd* 1.42 to 3 volumes of distilled water) at approximately 25°C; this acid may, however, dissolve some of the alloying elements in the case of some alloy coatings. Allow the basis metal and undercoat (if any) to dissolve completely. Decant, wash the residual coating several times with distilled water, and dry it at about 100°C.

C-3. FIRE ASSAY

C-3.0 The determination may be carried out on 5 mg of stripped coating but where possible, it is preferable to take a larger mass to obtain greater accuracy.

C-3.1 Procedure

C-3.1.1 Weigh the stripped coating on an assay balance to the nearest 0.01 mg; wrap in a sheet of lead foil (assay grade) together with a quantity of pure silver and a small piece of pure copper. The mass of the silver shall be 2 to 2.5 times that of the gold present and the mass of the copper shall be approximately 10 percent of that of the gold present. The mass of the lead foil shall be approximately 30 times the mass of the sample piece, with a minimum of 1 g. Cupel in a muffle furnace designed for gold assaying at a temperature of 1 100 to 1 150°C; flatten the resulting bead and anneal. Roll into a thin strip and re-anneal. ' Part ' the annealed strip in nitric acid (*rd* 1.2) followed by nitric acid (*rd* 1.3). In both cases the acid should be heated to boiling and kept just boiling throughout. Anneal and weigh the resulting gold ' Cornet ' to the nearest 0.01 mg.

C-3.1.2 One or more ' proof ' assays should be carried out alongside the sample assay, taking a known mass of pure gold corresponding approximately to that present in the sample piece and appropriate amounts of alloying elements.

C-3.2 Calculation

The gold content of the coating, as a percentage by mass, is given by the formula:

$$\frac{100 m_1}{m_2}$$

where

m_1 = is the mass, in milligrams, of the 'cornet' from the fire assay sample piece after applying any correction from the proof assay; and

m_2 = is the mass, in milligrams, of the stripped coating.

C-4. SPECTROPHOTOMETRIC AND ATOMIC ABSORPTION SPECTROMETRIC METHODS

Use the methods described in A-4.6 and A-4.7.

APPENDIX D

(Clauses 6.7.1 to 6.7.4)

ADHESION TESTS

D-1. BURNISHING TEST

D-1.1 Rub an area of not more than 6 cm² of the significant surface, selected at the discretion of the inspector, rapidly and firmly for 15 seconds with a suitable burnishing tool. An agate dental spatula with a handle 60 to 100 mm long and agate blade 30 to 50 mm long, 5 to 10 mm wide, sharpened to an edge similar to a cold chisel but slightly radiused (to avoid sharp edges) has been found very satisfactory. Apply a pressure sufficient to burnish the coating metal at every stroke, but not so great as to cut the coating. Check the specimen for signs of blistering or detachment of the coating.

D-2. ADHESIVE TAPE TEST*

D-2.1 Using a straightedge and a hardened steel scribe which has been ground to a sharp point, scribe a grid of 2 mm side squares over the test area. Apply a pressure sufficient to cut through the coating to the basis metal in a single stroke.

D-2.2 Then apply the adhesive side of a non-transferable adhesive tape, with an adhesion value of 2.9 to 3.1 N per centimetre of width (cellulose regenerated type) to the plating under test by finger pressure, taking care to exclude all air bubbles. After an interval of 10 seconds, remove the

*This test readily detects gross defects of adhesion.

tape by applying a steady pulling force on the tape, perpendicular to the surface of the plating under test. Check the specimen for signs of removal by the adhesive tape.

D-3. THERMAL SHOCK TEST

D-3.1 Raise the temperature of the sample to 200 to 300°C in air over a period of approximately 30 minutes, hold at this temperature for 10 to 60 minutes and cool by immersion in water at ambient temperature. Examine the coating for signs of blistering or detachment under a magnification of 8×.

NOTE — The temperature to which the sample should be heated and the duration over which this temperature should be maintained should be established for the coating/substrate combination being tested.

D-4. BEND TEST

D-4.1 Place the sample in a bend testing machine with a bending radius of 4 mm (or in the jaws of a suitable vice). Bend the sample as far as 90° backwards and forwards. For the purpose of this test, one bend shall constitute bending to 90° and back to its original position. Check the specimen for signs of detachment of the coating.

INDIAN STANDARDS

ON

ELECTROPLATING

IS:

- 1067-1981 Electroplated coatings of silver for decorative and protective purposes (*first revision*)
- 1068-1968 Electroplated coatings of nickel and chromium on iron and steel (*first revision*)
- 1337-1980 Electroplated coatings of hard chromium on iron and steel (*second revision*)
- 1359-1977 Electroplated coatings of tin (*second revision*)
- 1378-1979 Oxidized copper finishes (*second revision*)
- 1572-1968 Electroplated coatings of cadmium on iron and steel (*first revision*)
- 1573-1970 Electroplated coatings of zinc on iron and steel (*first revision*)
- 1771-1970 Electroplated coatings of silver for general engineering purposes (*first revision*)
- 1772-1972 Electroplated coatings of copper (*first revision*)
- 1773-1961 Brass plating
- 1992-1979 Electroplated coatings of lead (*first revision*)
- 4827-1968 Electroplated coatings of nickel and chromium on copper and copper alloys
- 4828-1968 Electroplated coatings of nickel and chromium on aluminium and aluminium alloys
- 4942-1968 Electroplated coatings of nickel and chromium on zinc and zinc alloys
- 8376-1977 Electroplated coatings of nickel and chromium on plastics for decorative purposes

INTERNATIONAL SYSTEM OF UNITS (SI UNITS)

Base Units

Quantity	Unit	Symbol
Length	metre	m
Mass	kilogram	kg
Time	second	s
Electric current	ampere	A
Thermodynamic temperature	kelvin	K
Luminous intensity	candela	cd
Amount of substance	mole	mol

Supplementary Units

Quantity	Unit	Symbol
Plane angle	radian	rad
Solid angle	steradian	sr

Derived Units

Quantity	Unit	Symbol	Definition
Force	newton	N	1 N = 1 kg.m/s ²
Energy	joule	J	1 J = 1 N.m
Power	watt	W	1 W = 1 J/s
Flux	weber	Wb	1 Wb = 1 V.s
Flux density	tesla	T	1 T = 1 Wb/m ²
Frequency	hertz	Hz	1 Hz = 1 c/s (s ⁻¹)
Electric conductance	siemens	S	1 S = 1 A/V
Electromotive force	volt	V	1 V = 1 W/A
Pressure, stress	pascal	Pa	1 Pa = 1 N/m ²

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